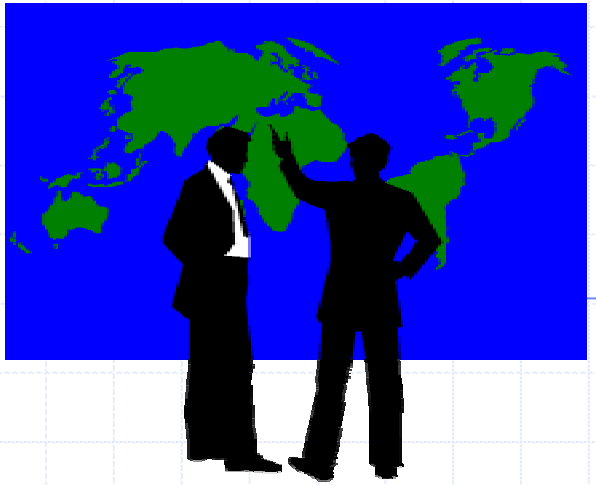
U.S. Department of Energy

OAK RIDGE NATIONAL LABORATORY

CHP Subcontractors Coordination Review Meeting



April 22, 2004
Oak Ridge National Laboratory's
Washington D.C. Office

Name of Contract and Subcontractors

Market Potential for Opportunity Fuels in DER/CHP Applications

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Description of Task(s)

- Objective: assess the use of alternative or opportunity fuels in DER/CHP applications

Opportunity Fuel: Any fuel that has the potential to be used for economically-viable power generation, but is not traditionally used for this purpose

- Approach:
  1. Collect and evaluate opportunity fuel information
  2. Explore DER/CHP technology options
  3. Develop potential market estimates and make recommendations

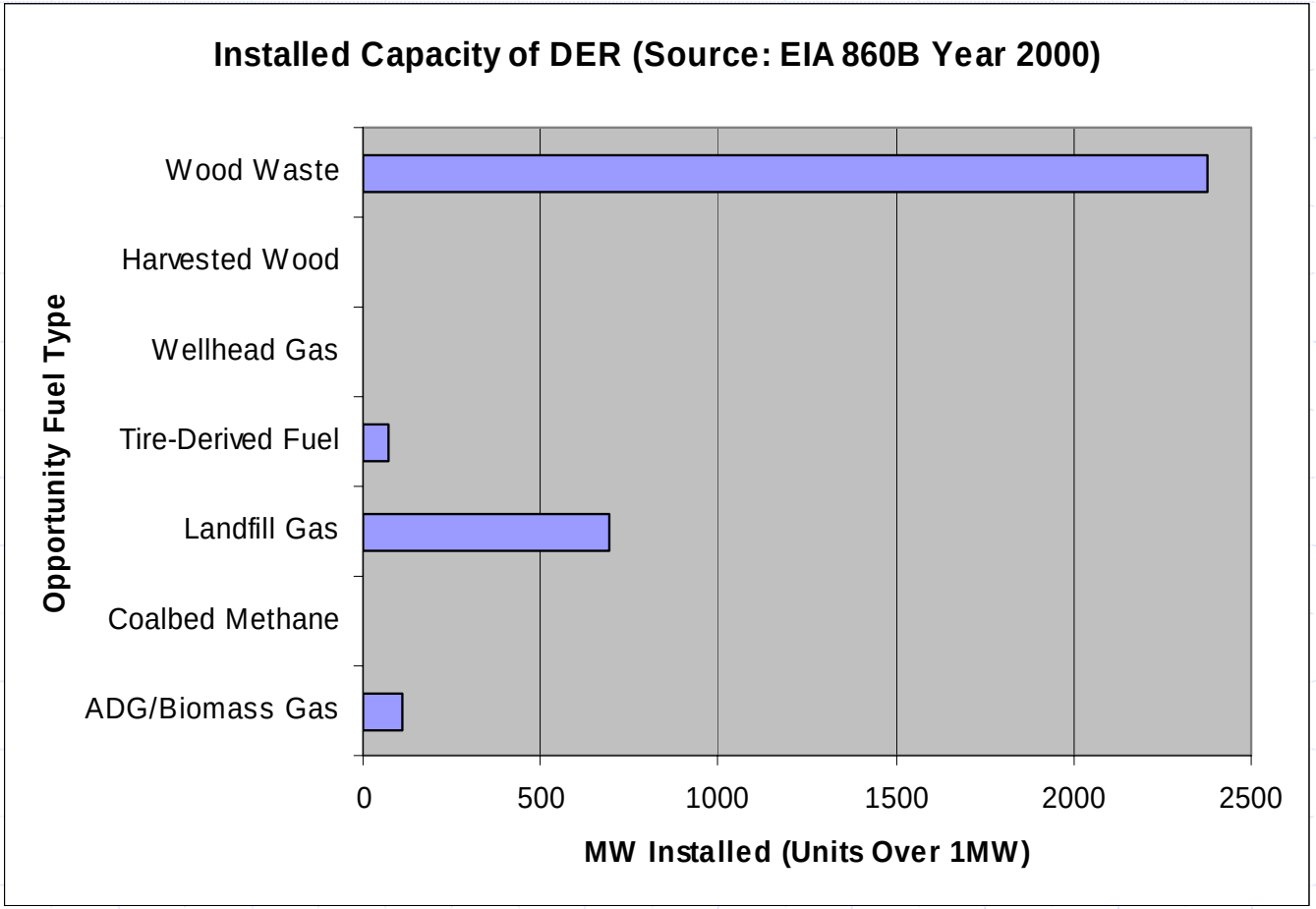
Description of Progress Against Task(s)

- Task 1. Collect Opportunity Fuel Information (Completed)
  - Reviewed previous studies
  - Collected information on opportunity fuels
    - Current status
    - Market considerations
    - Availability
    - Cost (acquisition, transportation, storage, processing)
    - Quality (Btus per cfm/pound, sulfur content, etc.)
    - Environmental issues
  - Screened fuels and selected the top fuels with the most potential for DER/CHP projects for further analysis

Description of Progress Against Task(s)

Opportunity Fuel	Availability	Heating Value	Fuel Cost	Equipment Cost	Emissions / Environment	DER/CHP Potential	Rating	Limitations	
Anaerobic Digester Gas	●	◑	●	◑	●	●	5.0	Need anaerobic digester	✓
Biomass (General)	●	◑	◑	◑	●	◑	4.0	Cost, usually cofired, broad cat.	
Biomass Gas	●	◑	◑	○	●	●	4.0	Gasifiers extremely expensive	✓
Black Liquor	○	◑	●	◑	◑	◑	3.0	Most BL already used up by mills	
Blast Furnace Gas	○	○	●	◑	◑	○	2.0	Limited availability, low Btu	
Coalbed Methane	◑	●	●	●	●	◑	5.0	Coal mines - lack CHP demand	✓
Coke Oven Gas	○	◑	●	◑	◑	◑	3.0	Availability - most already used	
Crop Residues	◑	◑	○	◑	●	◑	3.0	Difficulty in gathering/transport	
Food Processing Waste	◑	◑	●	◑	●	◑	4.0	Limited market, broad category	
Industrial VOC's	○	○	◑	◑	◑	◑	2.0	Must be used w/ NG turbine	
Landfill Gas	●	◑	●	◑	●	◑	4.5	Landfills – little demand for CHP	✓
Municipal Solid Waste	●	○	●	○	◑	◑	3.0	Low heating value, contaminants	
Orimulsion	○	●	◑	◑	◑	◑	2.5	Orimulsion not available in U.S.	
Petroleum Coke	●	●	●	◑	○	○	3.5	Many contaminants; large apps	
Sludge Waste	●	○	●	○	◑	○	2.5	Low heating value, contaminants	
Textile Waste	◑	◑	●	◑	◑	○	3.0	Must be cofired; larger apps	
Tire-Derived Fuel	●	●	◑	◑	◑	◑	4.0	Best suited for large apps	✓
Wellhead Gas	◑	●	●	◑	●	◑	4.5	Oil / gas wells – no CHP demand	✓
Wood (Forest Residues)	●	◑	◑	◑	●	◑	4.0	Fuel can be expensive	✓
Wood Waste	●	◑	●	◑	●	◑	4.5	Waste may have contaminants	✓

Description of Progress Against Task(s)



Description of Progress Against Task(s)

Fuel	Potential Thermal Output (Estimated, Trillion Btu/yr)	Potential Electric Capacity (Estimated, GW)
Anaerobic Digester Gas	1,000	38
Biomass Gas	3,000	110
Coalbed Methane	53	2
Landfill Gas	160	6
Tire-Derived Fuel	40	2
Wellhead Gas	3	0.1
Wood (Harvested)	270	10
Urban Wood Waste	220	8

- The potential thermal output was calculated assuming 40 percent thermal efficiency and a 6,000 hour operating year
- Potential electric capacity was calculated assuming a 30 percent electric efficiency

Description of Progress Against Task(s)

- Task 2. Evaluate CHP Technology Options (Completed)
  - CHP Technology price, performance, and emissions parameters were evaluated (new and retrofit technologies that can use the opportunity fuels)
    - Microturbines
    - Reciprocating engines
    - Combustion turbines
    - Steam turbine systems
    - Fuel cells
  - In some cases, existing technology can be used with little modification and no additional maintenance
  - In other cases, equipment and maintenance costs can double what they were “off-the-shelf” (with natural gas or coal)
  - Auxiliary equipment (gasifiers, filtration equipment, etc.) was also considered

Description of Progress Against Task(s)

- Impact of Opportunity Fuel on DER Technology Cost and Performance
  - The cost to modify or obtain DER/CHP equipment to run on opportunity fuels varies greatly depending on the application and size (for this project the size range is <1 to 50 MW)
  - Equipment manufacturers (Alstom, Dresser-Rand, Waukesha, Capstone, etc.) were contacted, and estimates were obtained
  - Example: A new gas turbine configured to run on landfill gas or anaerobic digester gas would require the following modifications:
    - New combustor
    - Modified nozzles
    - Larger manifolds
    - More filters/cleaning equipment

    In addition, the power output is reduced. Overall, equipment costs are doubled for low-Btu fuels (per kW) and variable maintenance costs are increased by 50-100 percent (per kWh)

Description of Progress Against Task(s)

Fuel	Cost	Steam Turbine*	Gas Turbine	Combined Cycle	Recip. Engine	Microturbine	Fuel Cell
Anaerobic Digester Gas	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$70 - $170 $650 - $1,650 $0.006 - $0.013	n/a $800 - $2,100 $0.006 - $0.011	n/a $725 - $2,500 $0.007 - $0.016	$170 - $390 $670 - $1,540 $0.013 - $0.039	$0 $970 - $2,030 $0.008 - $0.017	n/a $4,700 - $6,000 $0.012 - $0.018
Biomass Gas**	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$600 - $1,000 $1,260 - $2,650 $0.006 - $0.014	$600 - $1,000 $1,150 - $2,320 $0.005 - $0.011	$600 - $1,000 $1,150 - $2,760 $0.006 - $0.014	$600 - $1,000 $1,260 - $2,540 $0.009 - $0.026	$600 - $1,000 $1,590 - $3,090 $0.007 - $0.015	n/a $5,330 - $7,050 $0.013 - $0.021
Coalbed Methane	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$0 $600 - $1,500 $0.005 - $0.011	$0 $500 - $1,200 $0.004 - $0.008	$0 $500 - $1,600 $0.005 - $0.011	$0 $600 - $1,400 0.008 - $0.023	$0 $900 - $1,900 $0.006 - $0.012	n/a $4,300 - $5,500 $0.011 - $0.017
Landfill Gas	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$70 - $170 $650 - $1,650 $0.006 - $0.013	n/a $800 - $2,100 $0.006 - $0.011	n/a $725 - $2,500 $0.007 - $0.016	$170 - $390 $670 - $1,540 $0.013 - $0.039	$0 $970 - $2,030 $0.008 - $0.017	n/a $4,700 - $6,000 $0.012 - $0.018
Tire-Derived Fuel	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$0 $700 - $1,800 $0.006 - $0.014	n/a	n/a	n/a	n/a	n/a
Wellhead Gas	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	n/a	n/a	n/a	n/a	$0 $900 - $1,900 $0.008 - $0.017	n/a
Wood (Forest Residues)	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$140 - $420 $700 - $1,800 $0.006 - $0.014	n/a	n/a	n/a	n/a	n/a
Urban Wood Waste	Modify Existing Equip. ($/kW) New Equipment ($/kW) Maintenance ($/kWh)	$150 - $440 $740 - $1890 $0.007 - $0.015	n/a	n/a	n/a	n/a	n/a

*including boiler
**including gasifier

Description of Progress Against Task(s)

- Task 3. Develop Potential Market Impacts and Make Recommendations (In Progress)
  - A more in-depth analysis of availability and installed capacity for the 8 chosen opportunity fuels
  - The availability of each fuel's resources is examined on a state-by-state or even site-by-site in some cases

FY03 Deliverables and Availability

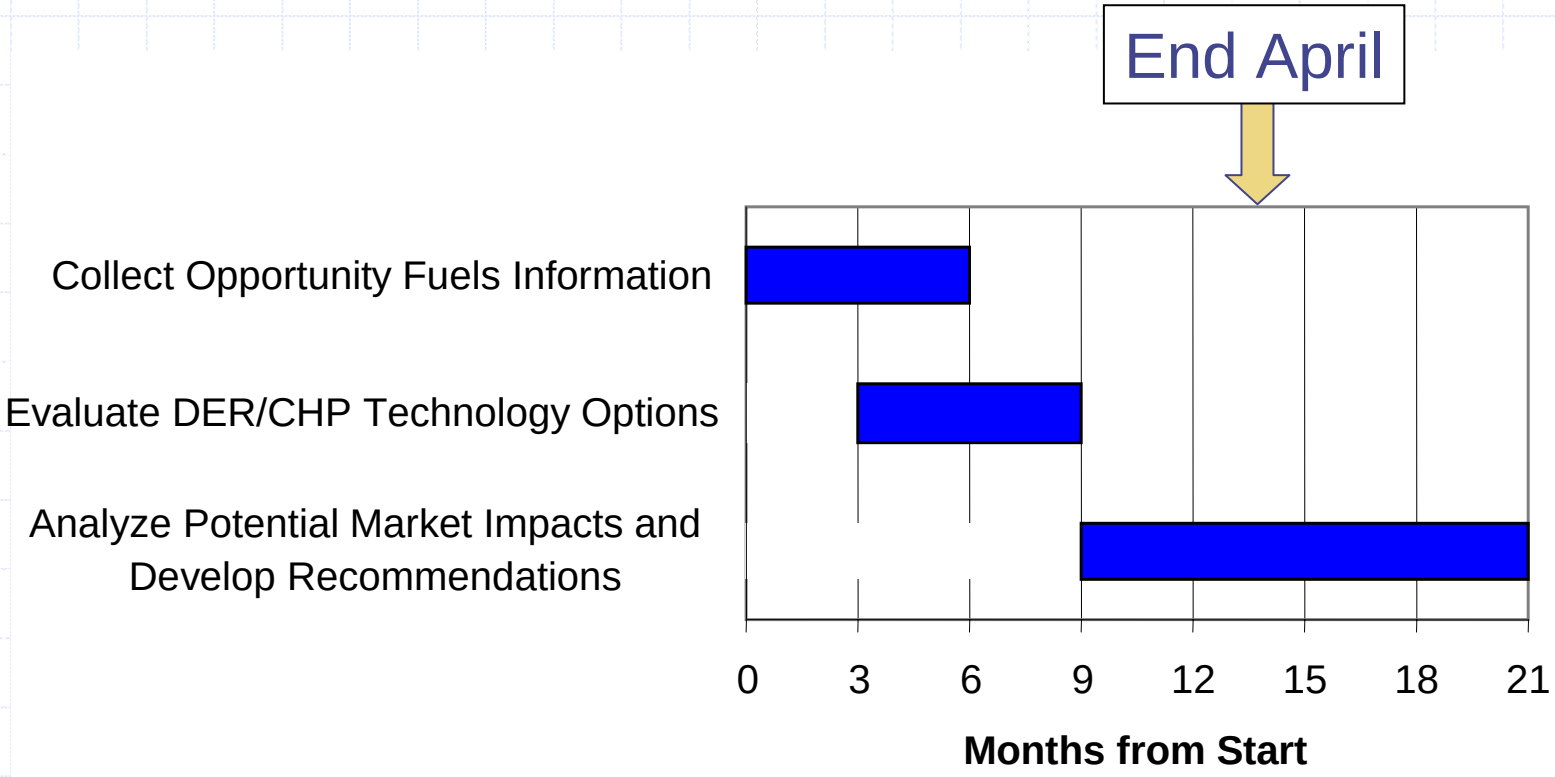
Deliverable	Status
Task 1 Status Report	Completed
Task 1 Draft Report	Completed
Task 2 Status Report	Completed
Task 2 Draft Report	Completed
Task 3 Status Report	Planned
Task 3 Draft Report	Planned
Draft/Final Report/PPT	Planned

- All deliverables will be available in PDF format for both hard copy and electronic delivery

Coordination with Stakeholder Groups and Other Project Teams

- Presented Interim Results to GTA
- Providing Draft Results to CHP Center Candidate
- Other Stakeholder Interactions being Considered

FY04-05 Timeline



Questions?